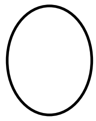
Critical Path Analysis

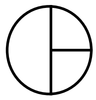
Specification requirement— Critical path analysis (CPA) – purpose, construction of networks, interpretation, benefits and limitations.

Critical path analysis, a type of network analysis, is a method of planning and controlling large projects. Large industrial projects such as building a bridge, or installing new machinery in a factory, are made up of tasks or activities that are inter-related—one task depends on another being complete. It is possible by the use of critical path analysis to plan the activities involved in completing complex projects, so that the overall project is completed in the most efficient manner possible.

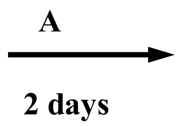
Critical path analysis is used to allocate resources within a project, judge how long a project should take to complete, and also to recognise those tasks or activities that take place within a project, that are critical to the project being completed on time. A critical task or activity, is one that must be started and completed on time if the project is to be finished on time.



A node. Nodes indicate the start or finish of tasks or activity. Each node is numbered.



Nodes are divided into 3 sections. In the left hand semicircle the node number is given. In the top right section the earliest start time of the next task or activity is entered, in the bottom right the latest finish time for the previous task is entered.



Arrows indicate a task or activity. Above the arrow will be a letter identifying the task, below the arrow, the amount of time taken to complete the task.

A broken arrow indicates a dummy task or activity.

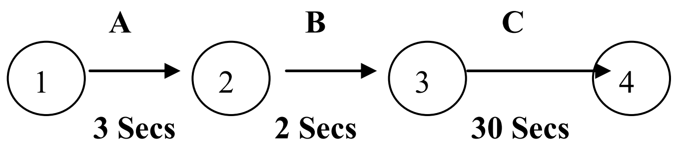
Task	Description	Time Taken
A	Toothpaste on Brush	3 seconds
B	Wet Brush Dependent on A	2 Seconds
C	Brush Teeth Dependent on C	30 seconds

Drawing Critical Path Diagrams

Above right we see the parts used in constructing a critical path network, (the terms tasks and activities are interchangeable). To see how we use the parts of the CPA diagram, we will draw a simple diagram.

To introduce the basics of drawing a CPA diagram we will use a very simple project that involves just three tasks. The project is brushing you teeth. The tasks involved are putting toothpaste on brush, wetting brush, then brushing teeth. Once we have times for each of these tasks we could lay out a table.

From the table we can prepare the CPA diagram. Below we have laid out the tasks in order, with numbered nodes starting and finishing each task. Tasks that follow on from each other form a path, so ABC form a path, with a total time of 35 seconds. If a task is dependent on another task, it cannot be started utill the other task is finished.



The previous example was quite simple, but we also need to see how to complete the information in the nodes, and to draw a complex CPA diagram, with more than one path. To see how to do this we will use the project of building a garden fence.

When constructing a CPA diagram you will be given information about the tasks involved. This information will tell you the duration of the task, and if the task is dependent on other tasks being completed. If a task is dependant on another, it cannot be started until the other task is complete. In the tooth brushing example, brushing teeth was dependant on toothpaste being on the brush.

The Fence Project

Task A Clearing the hedge is the first activity, everything else is dependent on this being done.

Task B is dependant on A

Task C is dependant on B. We can now complete this activity, but other activities involving the ordered parts will have to wait until they are delivered.

D. This is not dependent upon delivery of the parts, but is dependent on completion of activity A, and B

Task E can only start when C is complete (dependant on C)

Task F can only start when E is complete(dependant on E). The sinking of posts takes 1 hour, the concrete takes 3 hours to dry.

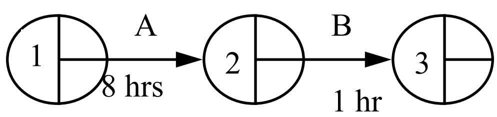
Task G can only start when F is complete(dependant on F)

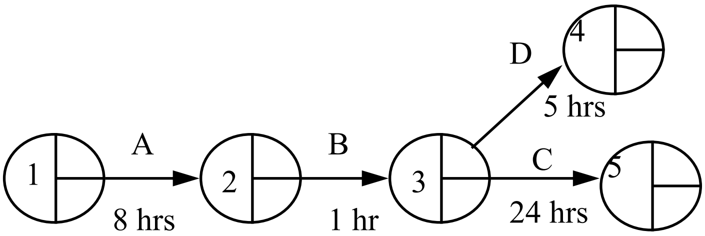
Task H can only start when C is complete(dependant on C) Task C includes ordering of nails, concrete and other parts.

	Tasks	Time
A.	**Clear hedge**	**8 hours**
B.	**Measure and calculate sizes and quantities**	**1 hour**
C.	**Order fence parts and delivery time**	**24 hours**
D.	**Dig holes for fence posts**	**5 hours**
E.	**Mix concrete and pour concrete**	**1 hour**
F.	**Sink posts into holes, and wait for concrete to set**	**4 hours**
G.	**Fix panels to posts**	**4 hours**
H.	**Paint panels with wood preserver.**	**3 hours**

If we were to total the above activities we would have a time for the project of 50 hours, but by drawing a network diagram we are able to sequence activities so that the project can be completed in the shortest possible time.

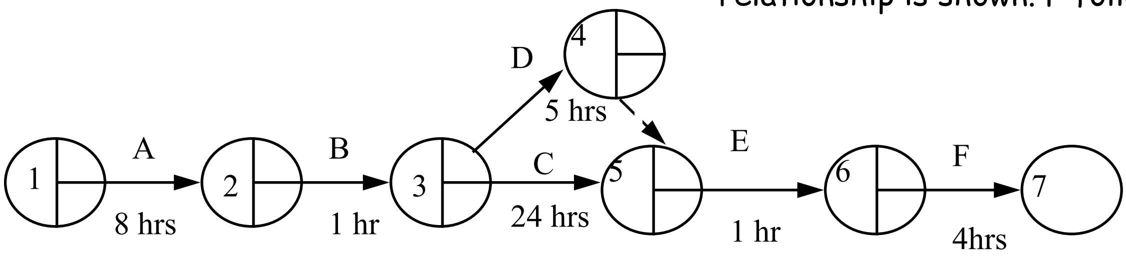
To construct our diagram we start with node 1, the start of the whole project that begins with activity A. At the end of activity A, we can add node 2, which indicates the start of activity B. This is shown below.



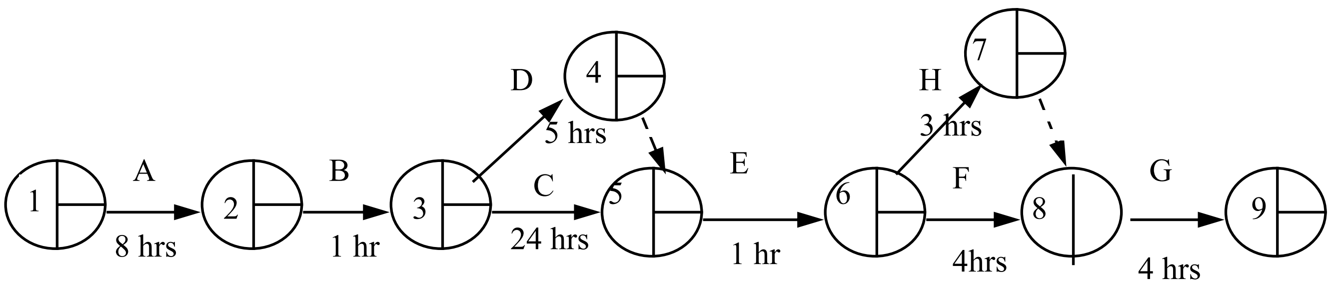


We now have two activities (C and D) taking place at the same time.

E is the next activity added. E is dependent on both D and C being completed, and this relationship is shown. F follows on from E.



H can occur at the same time as F, but is also dependent on E. So again we can add another path.
G is dependent on both H and F, so follows on from both of these.



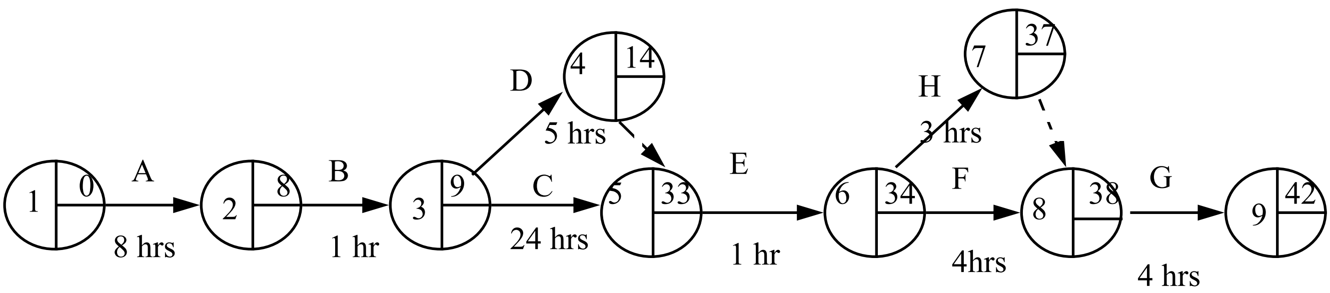
We have used 2 dummy activities, one connecting, 4 to 5, the other 7 to 8. We needed to use these dummy activities, so that we could show how the later activities (E and G), were dependent on the completion of earlier activities (D and H)

Once we have drawn the network, the next stage is to calculate Earliest Start Times and Latest Finish Times Once we have the EST's and LFT's we can then find the critical path.

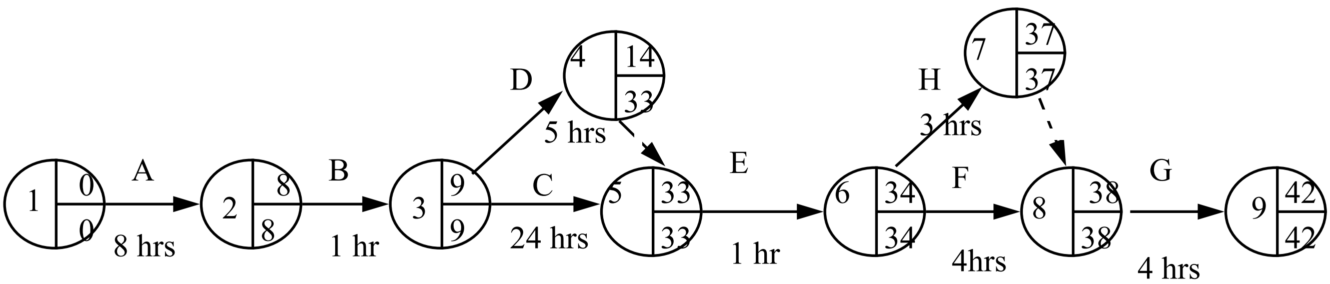
Earliest Start Times (EST's), and Latest Finish Times (LFT's)

To calculate critical path we first of all calculate the earliest start time, (EST) for each activity. To do this we start on the far left, in node 1. In the top right section we place a zero, as we can start the whole project with nil time so far used. In node 2, the EST will be 8 hours, the time taken for Activity A. In node 3, the EST of activities C and D, will be 9 hours, that is the time taken to complete activities A and B. which must precede (come before) C and D

The EST for activity E, will be the highest of the two paths that come together at node 5. So we have A,B and C, and A,B, and D. A,B,and C totals 33 hours, whilst A,B, and D totals 14 hours. So the EST for activity E is 33 hours, and this is placed in node 5.
We continue in this way until we have ESTs in each node. This is shown below.



The next stage is to calculate latest finish times. LFTs tell us the latest an activity can finish without delaying the overall project. To calculate LFTs we start on the far right and count our way back along the paths. The figure we start with is the EST in the final node, and we put this in the bottom right section of the final node. We now start to count back. 42 hours minus 4 hours for activity G gives us a LFT of 38 hours for activity F, this goes in node 7. Also because node 6 is joined by a dummy activity, with no time value, then the same LFT can be put in node 6. This means activity H has the same LFT as activity F.
Again count back, but now on two paths, When the paths join together at a node, in this case node 6, the lower LFT must be placed in the node.
The completed CPA diagram is shown below. The critical path is marked by those activities that are joined by nodes which have the same figure for EST and LFT in each node. There is no room for delay on this path. Any delay in finishing an activity, or starting an activity on this critical path will mean that the overall project will be delayed. The critical path is normally indicated by placing a > on each activity arrow on the path.



The project can be completed in 42 hrs, not the 50 hrs which is the total time of all the tasks.

Calculation of Floats.

A float is the spare time that may exist within a network for any specific activity, or collection of connected activities on the same path. There is never a float for any activity on a critical path.

There are two types of float that can be calculated, these are;

- ***the free float***
- ***the total float***

Free Float. This measures the amount of time an activity can be delayed, without delaying the overall project.

The fee float for an activity is calculated by using the following formula:

EST at end of an activity minus
(duration of activity plus EST at start of activity)

So on the network above the Free Float for activity D would be

33 minus (5 +9) = 19 hours free float.

Note. If there is a dummy activity follow dummy to next node for EST.

Total Float. This measures the free time available at a point on a path within a network. If there is only 1 activity on a path (as with activity D above), the Total Float will be the same as the Free Float, but if there is more than one activity on a path that is not the critical path use the following formula to calculate total float:

Total Float =
LFT of activity minus
(duration of activity plus EST of activity)

Failings of CPA.

CPA can give the wrong results, or fail to allow for external factors that will influence the total time taken. Examples of when CPA can go wrong are given below:

- Information has been distorted or poor methods of estimation of activity times have been used.
- Sub-contractors, who may be completing some of the activities on a project, can be outside the control of the project manager.
- Supplies may be delayed, may be of the wrong type, or of poor quality.

Advantages of using CPA.

- Allows effective management of resources, allocating factors, such as labour, to where they are needed and can be most effective.
- Reduces the need for working capital, parts used in the project can be ordered exactly when they are needed.
- Improves cash flow - as a result of reduced need for working capital.
- Improves overall management of projects - managers understand what is involved and what needs to be done and when it needs to be done.

notes